CHAPTER 1

INTRODUCTION

Section I - PRIMARY CONSIDERATIONS

1-1. Purpose and scope.

This manual provides guidance for the maintenance and repair of exterior electrical distribution systems. New construction of exterior electrical facilities, even when funded from maintenance appropriations, should comply with the appropriate design criteria. These systems include substations, overhead and underground electrical distribution systems, exterior lighting systems, and electrical apparatus and components. Guidance for generators and interior electrical systems (600 volts and less) are covered in the following publications:

a. TM 5-683/NAVFAC MO-l16/AFJMAN 32-1083.

b. TM 5-685/NAVFAC MO-912.

c. MIL-HDBK-1003A/ll.

1-2. References.

Appendix A contains a list of references used in this manual.

1-3. Application of codes and publications.

The information in this manual should not supersede equipment manufacturers' instructions and requirements. When conflicts exist the most rigorous requirement should be followed. A11 maintenance and repair of electrical systems should be performed in such a manner that the completed work will conform to the publications listed below to the degree indicated.

a. Codes. The listed codes and standard contain rules (both mandatory and advisory) for the safe installation, maintenance, and operation of electrical systems and equipment.

(1) The National Electrical Code (NEC), NFPA 70.

(2) The National Electrical Safety Code (NESC), ANSI C2.

(3) Occupational Safety and Health (OSHA), General Industry Standards, 29 CFR 1910.

b. Nongovernment publications. Other nongovernment publications referenced in this manual expand guidance in line with recognized industry standards. The most extended coverage on recommended practices for electrical equipment maintenance, and one that should be used in conjunction with both the NEC and the NESC, is NFPA 70B. Publication NFPA 70B is recommended as a useful reference in preparing contract requirements for maintenance to be done by outside service agencies.

1-4. Standards of maintenance.

Electrical systems will be regularly maintained to ensure continued compliance with the codes and publications referred to in appendix A. Such maintenance will prevent system and equipment failures and ensure maximum safety and efficiency in the utilization of the facilities. At each installation, a program for proper maintenance should be established and effectively followed. This program should include the scope of work, intervals of performance, and methods of application including safety requirements, practices and procedures. When a number of items require servicing or renewal over a period of years, a proportionate number should be maintained each year. For instance, if there are 100 transformers on the system, requiring maintenance at 5-year intervals, the work should be performed on 20 transformers each year.

a. Predictive maintenance. A predictive maintenance program is more desirable than routine recurring maintenance. Predictive testing should occur periodically but actual maintenance or replacement should take place only when necessary. An automated testing and record management system should be utilized where available. Where such a system is not available, its acquisition is recommended.

b. Sample testing formats. Testing formats for cable, circuit breakers, switchgear, and transformers are provided in NFPA 70B. These formats can be revised as needed for local requirements.

1-5. Maintenance responsibilities.

An adequate supply of dependable electrical energy is essential for the accomplishment of the installation mission. Adherence to a well planned and well organized maintenance program, including the establishment of specific goals and follow-up procedures will ensure the proper functioning of the equipment in the electrical distribution system.

a. Electrical supervisor. As used in this manual, the title electrical supervisor indicates the individual assigned the responsibility for maintenance of electrical distribution systems and equipment. The maintenance of electrical distribution systems is the responsibility of the installation's commander and a specific duty of an Army director of public

works, a Navy public works officer, or an Air Force base engineer. Operation and maintenance are a single staff responsibility, and frequently the same personnel will perform both functions.

b. Electrical supervisor responsibilities. The electrical supervisor will:

(1) Initiate positive action to remove, or reduce to a minimum, the cause of recurrent maintenance problems.

(2) Carry out maintenance inspections and services so there is a minimum of interference with user activities.

(3) Provide for the accomplishment of as much work as possible during each maintenance visit, and ensure that spot checks, inspections, and repairs are made on all components of the electrical facilities.

(4) Ensure that an adequate set of up-to-date records are maintained for each major component of all systems.

(5) Develop standard operating procedures which are in compliance with applicable safety requirements.

(6) Train maintenance personnel to improve their efficiency and to observe safety requirements.

1-6. Maintenance records.

One of the most important sources of information for aiding inspections, maintenance, or tests is a comprehensive file of equipment and service records. In addition to indicating basic information required for proper inspection of the equipment, these records will indicate where trouble has been experienced and where special procedures may be warranted.

a. Equipment documents. There are a variety of documents which indicate the equipment provided and how to keep it operating properly. These documents should be provided when new facilities are built, or existing facilities modified. These records should be obtained from the construction agency as soon as possible, preferably before the electrical supervisor accepts maintenance responsibility. These documents should address any warranty provisions applicable to the equipment. Equipment documents determine maintenance practices and should be included as a part of the maintenance records of the facility. The most common documents are listed below.

(1) *Instruction leaflets and manuals.* Each piece of major electrical equipment purchased should be accompanied by an instruction leaflet or manual outlining the desired methods of installation, operation, and maintenance. These instructions contain valuable information on maintenance practices, part designations, and ordering procedures. Spare parts lists are a vital part of these records.

(2) *Installation drawings.* Maintenance is often affected by the manner in which the equipment is installed. For convenience, and as a means of expediting maintenance, as-built installation drawings should be readily accessible to maintenance and inspection personnel.

(3) *Wiring diagrams.* Adequate and up-to-date wiring diagrams are important for proper maintenance. Diagrams facilitate locating troubles, which otherwise may require extensive probing and testing procedures. Such diagrams should be readily available to maintenance personnel.

(4) *Distribution maps.* Maps showing locations of distribution lines, wire sizes, transformer sizes, pole numbers, voltage classes, and sectionalizing devices are vital. Up-to-date distribution maps mounted on the maintenance or electrical shop wall are very useful.

b. Service records. Service records constitute a history of all work performed on each item of equipment and are helpful in determining the overall condition and reliability of the electrical facilities. Service records should show type of work (visual inspection, routine maintenance, tests, repair), test results (load, voltage, amperes, temperature), and any other remarks deemed suitable. It is highly recommended that service records should include a log of incidents and emergency operating procedures.

(1) *Logs of incidents.* Logs of incidents, such as power failures, surges, low voltage, or other system disturbances are very useful in planning and justifying corrective action.

(2) *Emergency operating instructions.* Emergency work on electrical facilities is safer and quicker when instructions are prepared and posted in advance. Instructions should be prepared for each general type of anticipated emergency, stating what each employee will do, setting up alternatives for key personnel, and establishing follow-up procedures. Instructions should be posted in the electrical shop, security guard office, substations, operating areas, and such other locations as the responsible supervisor deems advisable. Employees should be listed by name, title, and official telephone number. These instructions should emphasize safety under conditions of stress, power interruptions, and similar emergencies.

1-7. Priority and scheduling.

a. Priority. In regard to the support of the installation physical plant, it is the policy of the military

departments that, in order of priority, maintenance should be second only to operations. It must be systematic, and it must be timely.

b. Scheduling. The following chapters provide data on service intervals, procedures, and practices. Modifications may be made by installation commanders to meet local requirements. Service intervals may be lengthened only when justified by extenuating circumstances. Whenever service intervals or other guidance in this manual differs from information supplied by the manufacturer, the more stringent procedure should be followed.

Section II - SAFETY

1-8. Minimizing hazards.

Material specifications, construction criteria, installation standards, and safe working procedures have been developed to minimize hazards. All work and materials should conform to the latest accepted procedures and standards, as defined in publications listed or referred to in this manual.

1-9. Qualification of electrical workers.

Due to the inherent hazards encountered in the maintenance of electrical distribution systems and equipment, it is essential that all electrical workers be thoroughly trained and be familiar with the equipment and procedures to be followed.

1-10. Certification of electric workers.

Properly trained electric workers will be certified in accordance with applicable publications.

1-11. Public safety.

All necessary precautions will be taken to warn the public of electrical hazards or other conditions which may constitute a danger. This is especially true of temporary hazards due to work in progress.

1-12. Personnel safety.

Any work on or close to electrical equipment of any kind should be considered dangerous and proper safety precautions will be taken. All personnel who perform work of any kind on or near electrical equipment must be familiar with and observe all safety precautions.

a. Safety first. Two safety rules are mandatory as follows:

(1) Consider all electrical equipment to be energized until it is known positively (as by the presence of grounding clamps) that it is not energized. Comply with regulations and safety instructions contained in NEC and NESC, the applicable departmental publications, and special publications issued by the local command.

(2) Work may be done on energized lines and equipment only by personnel qualified by their job descriptions for that voltage level. Job descriptions should require actual hands-on work service periods which meet local utility and the International Brotherhood of Electrical Workers approval. All tools and equipment must be maintained in proper operating order, be suitable for the maximum voltage level involved, and should be periodically tested for compliance with all safety requirements. Departmental publications should be consulted for specific requirements in each voltage level.

b. Service safety manuals. This manual addresses some safety requirements, but users should also be familiar with the service safety manuals TM 5-682, NAVFAC P-1060, and AFMAN 32-1078.

c. Personal protective temporary grounding. This is temporary grounding installed to protect workers engaged in de-energized line maintenance. The grounds are provided to limit the voltage difference between any two accessible points at the work site to a safe value. An expanded discussion of protective grounding principles and practices is contained in IEEE 1048, NFPA 70B and "The Lineman's and Cableman's Handbook".

1-13. Live-line maintenance.

Aerial live lines are energized lines that are being tested, repaired, and maintained more and more by electrical utilities to reduce the number of outages or service interruptions. The use of such procedures on DOD installations requires that good practice be followed and that there is no conflict with local facility rules.

a. Good practice. Personnel doing live-line work should have satisfactorily completed a formal training course of instruction and be examined periodically. Live-line maintenance usually means any maintenance activity performed on energized electrical conductors or equipment with a phase-to-phase voltage exceeding 600 volts. It usually does not include such activities as switching, hardware tightening, climbing, hole digging, pole setting, conductor stringing, etc. The performance of this work requires equipment and tools that meet applicable industry standards for energized-line maintenance.

b. Local facility rules. Two considerations affect facility rules on the type and extent of live-line maintenance permitted: availability of qualified facility personnel and equipment versus the facility's requirement for uninterrupted operation. If local missions prevent electrical power shutdowns and local facilities are not qualified to perform live-line

work, then a live-line contractor may need to be hired on a scheduled and/or a nonscheduled basis. General energized-line maintenance practices covered in chapter 4, section VI, serve only as a guide and are not intended to substitute for training or operating procedures; for meeting specific industry guidelines; or for meeting federal, state, local, or facility regulations and rules.

Section III - AVOIDING PROBLEMS

1-14. Operating conditions.

Always observe the four cardinal rules of electrical maintenance.

a. Keep the equipment clean.

b. Keep the equipment dry or lubricated as appropriate to the part.

c. Keep screwed parts tight.

d. Prevent friction on moving parts.

1-15. Detecting potential trouble.

Diagnostic devices, where available, allow checking the system for potential trouble before it occurs. Potential problems may also be detected by the use of four of our five senses: see, hear, touch, and smell.

a. See. Many abnormal conditions can be detected by visual inspection: some of the patterns identifiable by sight are cleanliness, distortion, color, misalignment, size, and position.

b. Hear. Changes in the intensity of noise, pitch, or frequency are significant clues to operational changes and possible malfunctions. Some of the sound patterns that may indicate malfunctioning are squeaking, rattling, knocking, and whistling.

c. Touch. Among the damaging characteristics which may be identified by touch are vibration, wetness, and heat. Caution should be exercised in touching components which are normally hot enough to burn personnel on contact or live parts with hazardous potentials.

d. Smell. Burning insulation and battery fumes provide distinctive odors which signal component deterioration.

1-16. Electrical connections.

Connections are an essential part of any electric circuit. Good electrical contact is essential. Dirt is the enemy of good contact. Whenever an electrical connection is to be made, extreme care must be taken to ensure all dirt, rust, corrosion, insulation, oil, and other contaminants are removed. The contact surfaces should be bright, clean metal. This requirement applies to connections made by soldering, clamps, twisted sleeves, compression fittings, or any other method.

a. Aluminum. Connections of aluminum items should always include the application of a joint compound which will ensure metallic contact by dissolving the aluminum oxide which is always present on aluminum and aluminum alloy surfaces in air. The contact surfaces of aluminum conductors and connectors should first be vigorously cleaned with a stainless steel wire brush to a bright finish and then immediately coated with the aluminum-oxide inhibiting compound.

b. Copper. Copper contact surfaces should be cleaned, but not connector barrels. The barrels should be cleaned on the inside.

c. Dissimilar metals. Only connectors designed for the purpose should be used to connect aluminum and copper items.

d. Testing. Accessible connections may be tested using an infrared detector only if the connection is under load as covered in chapter 3, section I.